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TECHNICAL REPORT

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**EVALUATION OF TRIAL PROCUREMENT OF
REVERSIBLY COMPRESSED FREEZE-DRIED FOODS
INTRODUCTION**

by

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and

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Six types of reversibly compressed combination food bars were produced by Oregon Freeze-Dry Company. The bars were then stored for one year at 4.4, 21.1 and 38.0°C and evaluated at three month intervals for organoleptic evaluation, break score, rehydration ratio and rehydration scores. These bars meet many requirements for patrol type applications when food volume must be reduced to a minimum. However, most of the bars need improved texture and/or rehydration to make them as generally acceptable as Long Range Patrol Type Foods.		

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EVALUATION OF TRIAL PROCUREMENT OF
REVERSIBLY COMPRESSED FREEZE-DRIED FOODS

INTRODUCTION

Compression of freeze-dried foods into bars reduced the volume occupied by these freeze-dried foods. Freeze dehydration removes the moisture from food and makes it lighter, but does not result in a reduction in space required to carry the same amount of calories.

Tuomy (1971) reported on the first phase of a two-phase project with the Land Warfare Laboratory.³ The report listed formulas and discussed the technical problems in developing reversibly compressed combination food bars. Even though the reversibly compressed bars produced in the laboratory seemed quite promising, the question remained as to the feasibility of producing reversibly compressed combination food bars under commercial production conditions. Also, questions regarding storage stability of these products needed to be studied further since the limited time frame of phase I allowed only a quick storage test of 14 days at 51.7°C. Four general categories of foods were investigated of which only group I (combination animal products) will be discussed in this report

³ Tuomy, J. M. 1971. Development of reversibly compressed freeze-dried foods for use in individual ration packets. Technical Report FL 135, 72-4-F1 - 1974.

MATERIALS AND METHODS

Approximately 2500 compressed food bars were made of each of the following types: beef and vegetables, chicken and vegetables, chicken and brown rice, beef hash, chili con carne with beans, and beans and franks. These bars were produced at Oregon Freeze-Dry Foods Inc., under Reimbursible Order LWL 71-09. Many of the bars were used for field testing and the results of the field tests will be reported elsewhere. The bars not included in the field test were used in this study and were stored for 12 months at 4.4, 21.1, and 38.0°C. They were evaluated at 3, 6, 9, and 12 months for break score, rehydration ratio, rehydration scores, appearance, flavor, and texture.

The break score was determined by having the same individual break 3 bars per treatment. The bars were rated on a 1 to 5 scale where 1 represented a bar that was very difficult to break by hand; 3 represented a firm bar that snapped readily when broken by hand; and 5 was crumbly. A break score of 3 was considered desirable.

Rehydration was evaluated after the bars had been soaked in 82.2 to 93.3°C water for ten minutes without agitation. The bars were weighed dry and after draining for one minute following rehydration. These weights were used for calculating the rehydration ratio (rehydration ratio = rehydrated weight/dry weight). Each bar was broken into three pieces prior to rehydration. Rehydration scores were assigned to the same 3 bars per treatment used in the break score determination. A rehydration score of 1 was denoted as no water uptake; 5 (the preferred rating) was defined as well rehydrated without dry spots or over-rehydration. Rehydration scores from 6 to 9 represented progressive stages of over-rehydration.

Sensory evaluation (appearance, flavor, and texture) was accomplished for dehydrated and rehydrated reversibly compressed freeze-dried bars using an 8 to 11 member panel chosen from food chemists and technologists at the Natick Development Center. While panel size varied among products, panel size was constant for each product and each product was evaluated by the same panel throughout its storage period. The first samples received for testing had been stored for three months at 4.4, 21.1 and 38.0°C. These samples then represented the base line for comparing samples evaluated during the remainder of the storage study. Three 2.54 cm X 7.62 cm X 2.0 cm dehydrated bars of each product were individually divided into 4 parts for presentation to the sensory panel. The rehydration process began by breaking three bars into 12 pieces. Boiling water (300 ml) was added to the broken pieces of the three bars and allowed to rehydrate for ten minutes before serving. The mixture was stirred throughout the rehydration period. An extra 45 ml of boiling water was needed to rehydrate the chicken and vegetable bars for organoleptic evaluation.

RESULTS AND DISCUSSION

Difficulty was encountered in switching from laboratory production of reversibly compressed combination animal product bars to a commercial procurement. However, several adjustments were made to obtain the proper moisture content, dwell time, and pressure for compressing the food bars using equipment at Oregon Freeze Dry Foods Inc. The final compression parameters selected for each bar are reported in Table 17. These values are largely the result of the Natick Development Center's Mr. Hilton Schlup working directly with the people at Oregon Freeze Dry Foods.²

Beef and Vegetables

Results indicate that storage time up to twelve months did not affect the appearance, flavor, or texture of the unhydrated beef and vegetable bars (Tables 1, 4). While flavor was marginally acceptable, the texture was generally perceived as too dry in the unhydrated bars. As storage temperature was increased, flavor scores tended to be somewhat lower for unhydrated beef and vegetable bars. The attributes of texture and appearance remained unaffected by storage temperature (Table 1).

Longer storage times and high storage temperatures tend to affect adversely the appearance and texture of rehydrated beef and vegetable bars (Tables 2, 4). Rehydration and hardness of beef and vegetable bars were not affected by storage time or temperature (Table 3). The break scores (Table 5) and panel comments indicated the beef and vegetable bars to be on the hard side. The rehydration scores and ratios are indicative of the small dry spots found in the rehydrated material during sensory evaluation.

Chicken and Vegetables

Tables 1 and 6 indicate that increased storage time lowered the ratings for texture and appearance of unhydrated compressed chicken and vegetable bars while storage temperature only affected the flavor of the unhydrated bars even though the differences were not large. The only differences of any practical consequence would be more of texture and flavor at 38°C and 12 months storage.

Evaluation of the rehydrated samples indicated that the storage temperature had an effect on appearance and flavor (Table 2). One can see in Table 6 that the samples stored at 38.0°C were clearly unacceptable after 6 months in appearance and flavor. Increased storage time was also a significant ($P < .05$) factor for decreased flavor ratings even though this is only readily apparent in the bars stored at 38°C. Texture of the rehydrated bars was not affected by either storage time or temperature.

² Schlup, H.T., 1974. Private Communication.
Natick Development Center, Natick, MASS 01760

(Tables 2 and 6). From Table 3, one would think the storage variable affected hardness and rehydration of the chicken and vegetable bars. However, examination of table 7 reveals that the statistical significance of the treatments resulted from variation between cells due to variation in individual bars, rather than a deterioration of the examined attributes over storage time and temperature. The lack of uniformity noticed in hardness and rehydration may also be associated with the failure of storage time and temperature to exhibit an important effect on the texture of rehydrated reversibly compressed bars.

Chicken and Brown Rice

Chicken and brown rice bars crumbled while being removed from their flexible package. This fact is reflected in the break scores presented in Table 9. However, chicken and brown rice samples rehydrated very well. The crumbliness of the dry bar and the excellent rehydration of the chicken and brown rice bars accounts for the preference of the rehydrated texture versus the dry texture. For all practical purposes, the texture of these bars (Table 8) was affected more by the state of compression and rehydration than storage time or temperature.

The dry bars received good scores for flavor and appearance and were unaffected by storage time and temperature. Temperature and time were significant factors in deterioration of flavor noted in the rehydrated samples (Table 2) with the marked decreases observed for samples stored 9 to 12 months at 38.0°C (Table 8). The remaining rehydrated samples received good flavor scores. Storage temperature as it affects the appearance of rehydrated bars becomes an important factor only after 12 months storage at 38.0°C.

Beef Hash

The hardness somewhat increased during the storage period as shown in Table II. The sensory panel reflected the texture storage time effect only for the rehydrated samples. Most of this difference can be attributed to the better performance of samples at 21.1°C at 3 and 6 months. Texture of the rehydrated bars was also affected by storage temperature. The reason for this unexpected result is not clear and may in fact represent differences caused during processing rather than storage conditions. It is important to note in Table II that rehydration of beef hash bars was definitely a problem under conditions set for the rehydration test. The smaller pieces used in rehydrating the bar for sensory evaluation probably accounts for the texture scores being higher than would be expected with the rehydration scores reported in Table II.

Flavor (Table 10) is more of a problem with the dry bars than with the rehydrated bars. While flavor scores are generally lower for dry rather than rehydrated bars, the rehydrated bars scored well in flavor until the sample at 38.0°C for 12 months was evaluated. Flavor of dry bars tends to rate lower than desired after 9 months of storage at 38°C.

Significant effects were noted due to the effect of storage time and temperature on the appearance of rehydrated beef hash bars. Appearance of these bars was also affected by an apparent lack of uniformity in the distribution of potatoes and meat among bars and within individual bars and may account for the variation in mean values that fail to follow the general trends.

Chili Con Carne w/Beans

Storage time and temperature did not affect the break score, rehydration ratio, rehydration scores or the sensory attributes of appearance and texture of the dry compressed chili con carne w/beans (Tables 1,3). The break score for the dry bars indicates a desirable amount of hardness for the dry bar. Rehydration scores indicate some small dry spots were encountered after the prescribed rehydration period (Table 13). Table 12 shows the texture of the rehydrated bars to be quite acceptable in spite of some crunchiness and a significant decrease in texture ratings during the storage period, particularly after 12 months at 38°C.

The flavor of both dry and rehydrated bars decreased slightly with longer storage times and high storage temperatures (Tables 1, 1, 12). The flavor in the case of the dry sample was quite good at 3 months and of acceptable quality for this type of item after 12 months at 38°C. The flavor of the rehydrated sample held up well until it became unacceptable after 12 months storage at 38.0°C.

Appearance was unaffected in the dry state by storage temperature and time. Appearance ratings of rehydrated bars decreased after 12 months at 38°C.

Beans and Franks

The dry bean and frank bars were influenced somewhat by storage time for appearance, flavor, and texture (Tables 1, 14). Most of the effect was noticeable only after 12 months storage. Storage temperature also influenced the flavor of the dry bars. This trend seemed to develop after 6 months storage at 38°C. The dry bars seemed to be firm but broke easily when snapped by hand (Table 15). Table 14 shows the beans and franks to rate well as dry bars, one exception being flavor at 38.0°C and 12 months storage which rated rather low.

The flavor of the rehydrated bars was affected by storage temperature only. Appearance was affected by storage time (Table 2). The significance of the observations of the rehydrated beans and franks bars became questionable when they failed to rehydrate (Table 15). However, panel members commented that they liked the flavor and the crunchiness of the franks in water. Many comments reflected that this item had the appearance of a soup rather than an entree meat item.

CONCLUSIONS

The data indicate that the bars would be acceptable as a patrol type ration, but in the opinions of the authors they still lack the degree of acceptability that would be desired for complete replacement of the Long Range Patrol type food packet when product volume is not a consideration. The results of this test indicate the necessity for continued development work to establish a more favorable rehydration and texture of the dehydrated reversibly compressed food bars. When storage temperature and storage time were indicated as important variables in product quality by analysis of variance, further analysis showed these factors only contributed from 1 to 2% of the variance components (Hicks, 1956).³ Most of the variation could be attributed to the residual component of variance. The authors also noted considerable bar to bar variation in each group of reversibly compressed bars for texture and rehydration. It was thought that the variation in texture and rehydration might be closely associated with the observed variation in ingredient composition of each bar.

³ Hicks, C.R. 1956. Fundamentals of analysis of variance. Part II. The components of variance and the mixed model. Ind. Qual. Control 13:5

REFERENCE

- 1 Hicks, C. R. 1956. Fundamentals of analysis of variance. Part II. The components of variance and the mixed model. Ind. Qual. Control 13:5.
- 2 Schlup, H. T. 1974. Private Communication. Natick Development Center, Natick, Mass. 01760
- 3 Tuomy, J. M. 1971. Development of reversibly compressed freeze-dried foods for use in individual ration packets. Technical Report FL 135, 72-4-FL.

Table 1. Analysis of variance of taste panel results for dehydrated bars.

Bar	Appearance			Flavor			Texture		
	Storage Temperature	Storage Time	TXT ^A	Storage Temperature	Storage Time	TXT ^A	Storage Temperature	Storage Time	TXT ^A
Beef & Vegetables	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.
Chicken & Vegetable	N.S.	**	N.S.	**	N.S.	N.S.	N.S.	**	N.S.
Chicken w/brown Rice	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.
Beef Hash	N.S.	*	N.S.	*	*	N.S.	N.S.	N.S.	N.S.
Chili con Carne	N.S.	N.S.	N.S.	**	*	N.S.	N.S.	N.S.	N.S.
Beans & Franks	N.S.	**	N.S.	**	**	N.S.	N.S.	**	N.S.

* = P < 0.05

** = P < 0.01

N.S. = not significant at P < 0.05

TXT = Storage Temperature X Storage Time interaction.

Table 2. Analysis of variance of taste panel results for rehydrated bars.

Type of Bar	Appearance			Flavor			Texture		
	Storage Temperature	Storage Time	TXT ^a	Storage Temperature	Storage Time	TXT ^a	Storage Temperature	Storage Time	TXT ^a
Chicken and Vegetables	**	N.S.	N.S.	**	*	*	N.S.	N.S.	*
Chicken and Brown Rice	*	N.S.	*	**	**	**	N.S.	N.S.	N.S.
Beef Hash	*	*	*	**	**	*	**	*	N.S.
Chili con Carne	*	**	N.S.	**	**	**	N.S.	**	N.S.
Beans and Franks	N.S.	**	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.
Beef and Vegetables	**	*	N.S.	**	**	*	**	**	N.S.

* = $P < 0.05$

** = $P < 0.01$

N.S. = not significant at $P < 0.05$

^a TXT = Storage Temperature X Storage Time interaction.

Table 3. Analysis of variance results for break score, rehydration ratio and rehydration score.

Break Score		Rehydration Ratio		Rehydration Score	
Type	Temp.	Time	Temp.	Time	Temp.
Bar					
Beef and vegetables	N.S.	N.S.	N.S.	N.S.	N.S.
Chicken and vegetables	N.S.	**	**	*	**
Chicken and Brown Rice	N.S.	**	N.S.	N.S.	N.S.
Pork Hash	N.S.	**	N.S.	N.S.	**
Chili con Carne	N.S.	N.S.	N.S.	N.S.	N.S.
Beans and Franks	N.S.	N.S.	N.S.	N.S.	*

* = P ≤ 0.05

** = P ≤ 0.01

N.S. = not significant at P ≤ 0.05

TABLE 4. Beef and Vegetable. Appearance, flavor and texture of rehydrated and dehydrated bars.¹

Sensory Factors	Storage Temperature	3		6		9		12	
		Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³
Appearance	4.4°C	5.9	6.4	5.6	6.1	5.6	6.1	5.4	6.0
	21.1°C	5.6	6.4	5.6	6.0	5.4	6.1	5.5	6.1
	38.0°C	5.6	6.0	5.2	5.7	4.7	6.0	4.5	6.0
Flavor	4.4°C	5.7	5.1	5.6	4.6	5.6	4.9	5.6	5.1
	21.1°C	6.2	5.4	5.4	4.6	5.0	5.0	5.0	4.7
	38.0°C	6.9	4.4	5.4	4.9	5.4	4.0	5.7	4.6
Texture	4.4°C	5.6	4.9	5.5	4.7	5.4	4.6	5.4	4.6
	21.1°C	5.9	4.5	5.6	4.7	5.5	4.6	5.2	4.4
	38.0°C	5.6	4.9	5.4	4.7	5.0	4.2	4.4	4.6

1 Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

2 N = 8 Rehydrated

3 N = 8 Dehydrated (dry)

TABLE 5. Beef and Vegetable. Break score, rehydration ratio, and rehydration score.

Test	Storage Temperature	Storage Time (Months)			
		3	6	9	12
Break ₁ Score	4.4°C	2.7	2.5	2.3	2.6
	21.1°C	3.0	2.7	2.6	3.7
	38.0°C	3.3	2.3	2.7	3.0
Rehydration Ratio ²	4.4°C	3.805	3.500	3.756	3.688
	21.1°C	3.160	3.391	3.981	3.790
	38.0°C	3.763	3.762	2.790	4.162
Rehydration Score ³	4.4°C	4.0	3.3	4.0	3.3
	21.1°C	3.3	3.0	5.0	4.0
	38.0°C	3.7	3.3	5.0	4.3

¹ Break Score: 1 = difficult to break by hand; 3 = firm bar that snaps readily; 5 = crumbly.

² Rehydration Ratio: = rehydrated weight/dry weight

³ Rehydration Score: 1 = slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated

TABLE 6. Chicken and Vegetable. Appearance, flavor and texture of rehydrated and dehydrated bars.¹

Sensory Factors	Storage Temperature	3		6		9		12	
		Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³
Appearance	4.4°C	5.4	6.8	5.5	6.8	5.4	6.6	5.5	6.4
	21.1°C	5.5	6.6	5.4	6.5	5.2	6.7	5.4	6.4
	38.0°C	5.1	6.8	5.0	6.6	4.7	6.5	4.6	6.2
Flavor	4.4°C	6.2	6.1	5.9	6.0	5.6	5.8	6.2	5.6
	21.1°C	6.0	6.1	6.2	5.4	6.0	5.8	6.2	5.4
	38.0°C	5.9	5.4	4.3	5.4	4.5	5.2	4.8	5.3
Texture	4.4°C	5.5	6.0	5.3	6.0	4.9	5.6	5.2	5.6
	21.1°C	4.6	6.1	5.4	5.8	5.4	5.6	5.4	5.4
	38.0°C	4.7	5.9	5.0	5.6	5.2	5.5	5.0	5.3

¹ Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

² N = 11 Rehydrated

³ N = 11 Dehydrated

TABLE 7. Chicken and Vegetables. Break score, rehydration ratio, and rehydration score.

Test	Storage Temperature	Storage Time (Months)			
		3	6	9	12
Break Score ¹	4.4°C	2.8	3.7	2.0	2.7
	21.1°C	3.0	1.8	2.0	2.3
	38.0°C	3.5	1.8	2.0	2.3
Rehydration Ratio ²	4.4°C	2.028	4.005	2.685	3.530
	21.1°C	2.822	3.310	2.557	3.008
	38.0°C	3.985	3.652	3.225	3.785
Rehydration Score ³	4.4°C	3.0	4.3	1.7	3.0
	21.1°C	2.0	2.7	1.0	3.0
	38.0°C	4.3	2.7	1.7	3.3

¹ Break Score: 1 = difficult to break by hand; 3 = firm bar that snaps readily; 5 = crumbly.

² Rehydration Ratio = rehydrated weight/dry weight.

³ Rehydration Scores: 1 = Slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated.

TABLE 8. Chicken and Brown Rice. Appearance,¹ flavor and texture of rehydrated and dehydrated bars.

Sensory Factors	Storage Temperature	3		6		9		12	
		Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³
Appearance	4.4°C	5.9	5.3	5.9	4.8	5.9	5.1	6.2	4.9
	21.1°C	5.8	5.1	5.9	5.0	5.9	4.8	5.8	5.0
	38.0°C	5.9	5.1	5.9	5.1	5.7	6.1	5.0	5.0
Flavor	4.4°C	6.3	6.2	6.3	5.6	5.6	5.6	5.8	5.7
	21.1°C	6.2	5.9	5.9	5.8	5.9	5.8	5.7	5.7
	38.0°C	6.2	5.6	5.8	5.7	5.1	5.2	3.6	5.3
Texture	4.4°C	5.3	5.1	6.1	4.8	5.8	4.7	6.2	4.8
	21.1°C	5.9	5.1	5.7	4.9	5.8	4.7	5.8	4.7
	38.0°C	5.9	5.1	5.9	4.9	5.6	4.6	5.7	4.7

¹ Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

² N = 10 Rehydrated

³ N = 10 Dehydrated

TABLE 9. Chicken and Brown Rice, break score, rehydration ratio, and rehydration score.

Test	Storage Temperature	3		6		9		12	
Break Score ¹	4.4°C	5.0		5.0		5.0		5.0	
	21.1°C	4.7		5.0		5.0		5.0	
	38.0°C	4.7		5.0		5.0		5.0	
Rehydration Ratio ²	4.4°C	3.798		3.650		3.703		3.713	
	21.1°C	3.706		3.732		3.956		3.783	
	38.0°C	3.950		3.533		3.654		3.652	
Rehydration Score ³	4.4°C	5.0		4.7		4.7		5.0	
	21.1°C	5.0		5.0		5.0		5.0	
	38.0°C	5.0		5.0		4.7		5.0	

¹ Break Score: 1 = difficult to break by hand; 3 = firm that snaps readily; 5 = crumbly.

² Rehydration ratio = rehydrated weight/dry weight.

³ Rehydration score: 1 = slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated.

TABLE 10. Beef Hash. Appearance, flavor and texture of rehydrated and dehydrated bars.¹

Sensory Factors	Storage Temperature	Storage Time (Months)							
		3		6		9		12	
		Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³	Rehy- drated ²	Dehy- drated ³
Appearance	4.4°C	5.4	6.1	5.2	6.5	5.5	6.2	4.9	6.2
	21.1°C	5.8	6.3	5.5	6.3	5.2	6.1	5.7	6.2
	38.0°C	5.3	6.5	5.1	6.5	5.6	6.3	4.3	5.8
Flavor	4.4°C	6.1	5.4	5.8	5.7	5.5	5.2	5.7	
	21.1°C	6.3	6.1	5.9	5.4	5.9	4.8	5.7	5.6
	38.0°C	5.7	5.7	5.3	5.0	5.4	4.7	3.6	4.8
Texture	4.4°C	5.3	5.4	5.4	5.3	5.3	5.3	4.9	5.4
	21.1°C	5.9	5.6	5.4	5.3	5.4	5.1	5.5	5.3
	38.0°C	5.4	5.5	5.3	5.4	5.1	5.2	4.5	5.3

¹ Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

² N = 10 Rehydrated

³ N = 10 Dehydrated

TABLE 11. Beef Hash. Break score, rehydration ratio and rehydration score

Test	Storage Temperature	Storage Time (Months)			
		3	6	9	12
Break Score ¹	4.4°C	3.3	2.3	2.0	2.3
	21.1°C	3.7	2.7	2.0	2.3
	38.0°C	3.0	2.0	2.3	2.3
Rehydration Ratio ²	4.4°C	2.441	2.834	2.142	2.773
	21.1°C	2.622	2.734	2.082	2.604
	38.0°C	2.487	2.997	2.046	2.589
Rehydration Score ³	4.4°C	1.0	2.0	1.0	2.7
	21.1°C	1.2	2.0	1.7	1.3
	38.0°C	1.0	2.0	1.7	1.7

¹ Break score: 1 = difficult to break by hand; 3 = firm bar that snaps readily; 5 = crumbly.

² Rehydration Ratio = rehydrated weight/dry weight.

³ Rehydration Score: 1 = slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated.

TABLE 12. Chili con Carne with Beans. Appearance, flavor and texture of rehydrated and dehydrated bars.

Sensory Factors	Storage Temperature	Storage Time (Months)							
		3	6	9	12	3	6	9	12
		Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated
Appearance	4.4°C	6.3	6.0	6.4	5.9	6.3	6.0	6.0	5.8
	21.1°C	6.4	6.1	6.3	5.9	6.1	6.0	6.0	5.9
	38.0°C	6.4	6.1	6.3	5.9	5.9	6.0	5.2	5.8
Flavor	4.4°C	6.4	5.9	6.0	5.9	6.3	5.5	6.3	5.8
	21.1°C	6.4	6.0	6.4	5.8	6.0	6.0	5.7	5.9
	38.0°C	6.4	6.0	6.0	5.4	5.4	5.1	2.4	5.3
Texture	4.4°C	5.9	5.2	6.0	5.4	5.8	5.4	5.4	5.3
	21.1°C	6.1	5.4	5.9	5.4	5.9	5.3	5.4	5.4
	38.0°C	5.9	5.3	5.9	5.4	5.4	4.8	4.5	5.1

¹ Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

² N = 11 Rehydrated

³ N = 11 Dehydrated

TABLE 13. Chili Con Carne with Beans. Break score, rehydration ratio, and rehydration score.

Test	Storage Temperature	Storage Time (Months)			
		3	6	9	12
Break ₁ Score	4.4°C	3.2	3.3	4.3	3.0
	21.1°C	2.7	2.7	3.0	3.7
	38.0°C	2.7	3.3	3.7	3.0
Rehydration ₂ Ratio	4.4°C	2.466	2.531	2.570	2.346
	21.1°C	2.731	2.413	2.701	2.797
	38.0°C	2.557	2.566	2.555	2.518
Rehydration ₃ Score	4.4°C	3.0	3.7	3.0	3.3
	21.1°C	3.3	2.7	3.7	4.0
	38.0°C	3.7	3.3	2.7	3.7

¹ Break Score: 1 = difficult to break by hand; 3 = firm bar that snaps readily; 5 = crumbly.

² Rehydration Ratio = rehydrated weight/dry weight.

³ Rehydration Score: 1 = slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated.

TABLE 14. Beans and Franks. Appearance, flavor and texture of rehydrated and dehydrated bars. ¹

Sensory Factors	Storage Temperature	Storage Time (Months)							
		3		6		9		12	
		Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated	Rehy- drated	Dehy- drated
Appearance	4.4°C	5.6	5.9	5.6	5.9	5.3	5.7	5.1	5.5
	21.1°C	5.3	5.8	5.5	5.9	5.2	5.8	5.2	5.4
	38.0°C	5.1	6.1	5.6	5.9	5.0	5.8	5.0	5.5
Flavor	4.4°C	6.2	6.2	5.7	5.7	6.1	5.9	6.0	5.8
	21.1°C	5.8	5.9	5.6	5.9	4.8	5.7	5.8	5.3
	38.0°C	5.7	6.1	5.4	5.5	5.6	5.1	5.1	4.6
Texture	4.4°C	5.6	5.5	5.7	5.6	5.8	5.6	5.2	5.2
	21.1°C	5.4	5.5	5.6	5.7	5.4	5.6	5.6	5.2
	38.0°C	5.5	5.5	5.8	5.6	5.5	5.4	5.4	5.0

¹ Sensory factors rated on a one-to-nine scale (1 = extremely poor, 9 = excellent)

² N = 10 Rehydrated

³ N = 10 Dehydrated

TABLE 15. Beans and Franks. Break score, rehydration ratio, and rehydration score.

Test	Storage Temperature	Storage Time (Months)			
		3	6	9	12
Break Score ¹	4.4°C	4.7	2.3	3.5	3.7
	21.1°C	3.3	3.0	2.5	3.3
	38.0°C	2.3	4.0	3.0	4.0
Rehydration Ratio ²	4.4°C	1.988	1.488	1.494	1.698
	21.1°C	1.963	1.627	1.510	1.510
	38.0°C	1.673	1.77	1.624	1.917
Rehydration Score ³	4.4°C	1.0	1.0	1.3	2.0
	21.1°C	1.0	1.3	1.3	1.8
	38.0°C	1.0	1.3	2.0	2.3

¹ Break score: 1 = difficult to break by hand; 3 = firm bar that snaps readily; 5 = crumbly.

² Rehydration ratio = rehydrated weight/dry weight.

³ Rehydration score: 1 = slight to no water uptake; 5 = proper rehydration; 9 = over rehydrated.

TABLE 16. Formulation of Reversibly Compressed Combination
Animal Product Bars.

A) Beef with Vegetables

<u>Components</u>	<u>Percent by Weight</u>
Beef, cooked, diced (12.7 mm by 12.7 mm X 6.3 mm)	25.0
Potatoes, diced, raw (9.5 mm by 9.5 mm by 9.5 mm)	25.0
Peas, Split	10.0
Carrots, diced (9.5 mm Cube)	10.0
Water	27.0
Seasonings	<u>3.0</u>
	100.0

<u>Seasonings</u>	<u>Percent by Weight</u>
Salt	43.0
Onion, dehydrated, minced	10.0
Sugar	10.0
Celery salt	10.0
Starch, instant	10.0
Onion powder	5.0
Hydrolyzed vegetable protein	5.0
Caramel coloring	5.0
Pepper, white	1.0
Monosodium glutamate	<u>1.0</u>
	100.0

Diced raw potatoes shall be cooked separately in water. They shall be slightly undercooked and rinsed with cold water. Split peas and diced carrots shall be cooked separately in water until tender. Seasonings shall be placed in water and heated while stirring to 82.2°C and allowed to stand five minutes. Vegetables and cooked diced beef shall be added to the gravy sauce and heated while stirring to 82.2°C. Care should be taken to minimize amount of time the vegetables are heated in the gravy sauce. Freeze at -17.8°C.

B) Chicken and Vegetables

<u>Components</u>	<u>Percent by Weight</u>
Potatoes, diced, raw (9.5 mm cube)	27.00
Chicken, cooked, diced (12.7 mm by 12.7 mm by 6.3 mm)	20.00
Peas, split, raw	9.00
Carrots, diced, raw	9.00
Seasoning	4.53
Water	<u>30.47</u> 100.00

<u>Seasonings</u>	<u>Percent by Weight</u>
Milk, nonfat, dry	35.00
Salt	19.41
Starch, instant	15.00
Sugar	15.00
Celery Salt	5.00
Onions, dehydrated, minced	5.00
Hydrolyzed vegetable protein	3.00
Onion powder	1.50
Pepper, white	0.60
Poultry seasoning, ground	0.25
Monosodium glutamate	0.15
Garlic powder	<u>0.09</u> 100.00

Diced raw potatoes shall be cooked separately in water. They shall be slightly undercooked and rinsed with cold water to prevent overcooking. Split peas and diced carrots shall be cooked separately in water until tender and then rinsed with cold water. Seasoning shall be placed in water and heated while stirring to 82.2°C and allowed to stand for five minutes. Vegetables and diced cooked chicken shall be added to the gravy sauce and heated while stirring to 82.2°C. Freeze at -17.8°C.

C) Chicken and Brown Rice

<u>Components</u>	<u>Percent by Weight</u>
Chicken, cooked, diced (12.7 mm by 12.7 mm by 6.3 mm)	30.00
Rice, cooked, brown	33.0
Pimentos, diced (9.5 mm Cube)	10.0
Seasonings	3.0
Water	<u>24.0</u> 100.00

<u>Seasonings</u>	<u>Percent by Weight</u>
Salt	39.5
Starch, instant	15.0
Sugar	13.0
Onions, dehydrated, minced	12.0
Celery salt	10.0
Onion powder	5.0
Hydrolyzed vegetable protein	2.0
Poultry seasoning	2.0
Monosodium glutamate	1.0
Pepper, white	<u>0.5</u> 100.00

Mix seasoning with water and heat to 82.2°C while stirring. Add pimentos, stir, add the cooked brown rice, stir; and then add the diced cooked chicken. The product shall be heated to 82.2°C while stirring.

D) Beef Hash

<u>Components</u>	<u>Percent by Weight</u>
Beef, raw, 9.5 mm grind (9 to 12% fat)	42.5
Potatoes, diced, raw (9.5 mm by 9.5 mm by 9.5 mm)	41.0
Hash seasoning mix	3.0
Water	<u>13.5</u> 100.00

<u>Hash Seasoning mix</u>	<u>Percent by Weight</u>
Soup and gravy base, beef flavored	54.6
Onion powder	29.7
White pepper	1.0
Garlic powder	0.1
Monosodium glutamate	0.3
Salt	<u>14.3</u> 100.00

Diced potatoes shall be placed in water and boiled until they are slightly uncooked to ensure proper texture after compression. They shall be rinsed in cold water after cooking is complete. Seasonings and water shall be heated with stirring to 82.2°C. Ground beef shall be added and the mixture heated with stirring until the red color of the meat disappears and the mixture reaches a minimum temperature of 82.2°C. The slightly undercooked potatoes shall be added and the mixture again heated to 82.2°C. Freeze at -17.8°C for freeze-drying.

E) Chili Con Carne with Beans.

<u>Components</u>	<u>Percent by Weight</u>
Beef, raw, 9.5 mm grind (9 to 12% Fat)	42.25
Beans, red, kidney (12% moisture)	21.50
Chili seasoning	3.75
Water	20.50
Tomato paste	<u>12.00</u> 100.00

Beans shall be cooked. If moisture in the dry beans varies more than 1.0% from 12.0%, water in the formula shall be adjusted.

<u>Chili Seasoning</u>	<u>Percent by Weight</u>
Soup and gravy base, beef flavored	44.0
Chili powder	34.0
Salt	18.0
Garlic powder	0.3
Onion powder	3.2
monosodium glutamate	0.1
Pepper, red	<u>0.4</u> 100.00

Seasoning and water shall be heated with stirring to 82.2°C. Beef shall be added and the mixture treated with stirring until the red color of the meat disappears and the mixture reaches a minimum temperature of 82.2°C. Tomato paste and cooked beans shall be added and the mixture heated to a maximum of 82.2°C. Freeze at -17.8°C.

F) Beans and Franks

<u>Components</u>	<u>Percent by Weight</u>
Frankfurters, all beef (3.2 mm slices)	19.0
Beans, Navy, Cooked	35.0
Tomato puree	13.5
Dry Mix	2.0
Water	22.0
Catsup	7.5
Vinegar	<u>1.0</u>
	100.0

<u>Dry Mix</u>	<u>Percent by Weight</u>
Soup and gravy base, beef flavored	37.3
Sugar	24.3
Worcestershire sauce	18.7
Onion, dehydrated, minced	14.9
Paprika	1.9
Mustard, dry	1.3
Pepper, red	0.7
Pepper, black	0.7
Garlic powder	<u>0.2</u>
	100.0

Combine dry mix and water. Heat to 82.2°C with stirring and allow to stand for 5 minutes. Add tomato puree, catsup and vinegar with stirring and again heat to 82.2°C. Add the frankfurters and cooked beans and heat the product to 82.2°C with stirring. Freeze at -17.8°C for freeze-drying. Formula = A through F were freeze dried with a product temperature not to exceed 65.5°C and a chamber pressure not to exceed 1.5 mm Hg (0.2 k pa.)

Table 17. Compression parameters for reversibly compressed food bars.

<u>Product</u>	<u>N/M²*</u>	<u>Dwell Time (seconds)</u>	<u>% Moist**</u>
Chili con Carne	3.4×10^6	6	11.7
Beef Hash	2.1×10^6	9	10.8
Beef w/Vegetables	2.4×10^6	9	12.0
Chicken w/Vegetables	3.4×10^6	9	12.9
Chicken w/Brown Rice	1.4×10^6	6	8.6
Beans and Franks	1.0×10^6	3	9.0

* N/M² = Newton/meter²; N/M as determined at Oregon Freeze-Dry.

** % moisture determined by Toluene distillation. The dry product was sprayed to the indicated moisture level and allowed to equilibrate 48 hours prior to pressing. This moisture was subsequently removed after compression was accomplished and before packaging bars.